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ELECTRO-MAGNETISM.

The Electro-magnet and Electro-magnetic Mechanism. By S. P. Thompson, D.Sc., F.R.S. (London: E. and F. N. Spon, 1891.)

THIS is a reprint, with additions, of a course of Cantor Lectures which the author delivered during 1890 before the Society of Arts. The book, it may be stated at the outset, is an excellent account of electro-magnetic mechanism, and abounds in information at once of historical, scientific, and practical value. Evidently the author is willing to spare no pains to give completeness to any work of this kind he undertakes, and the present book, like his treatise on dynamo-electric machinery, will no doubt be widely read and appreciated.

In the preface, and elsewhere in the body of the book itself, Dr. Thompson indulges in some statements which we think are a blemish on an excellent and well-written treatise. It serves no good purpose to distribute in a scientific book praise or blame to certain classes of scientific investigators, and while glorifying a certain section of workers, to pour what seems little short of contempt and derision on the labours of another. We refer here to the statements (chiefly in the preface) regarding the earlier mathematical theories of magnetism, and their alleged influence in retarding electro-magnetic discovery.

It is quite true that some of the older theorists, concentrating their attention on the magnetic field of a system of permanent magnets, gave only a secondary attention to the problem of the internal constitution of a magnet. But it is hardly fair to put down against them, by inference, the errors of the persons who persisted in assuming that, because it had been proved that a magnet produces a field which can also be accounted for by a distribution of imaginary magnetic matter over the surface of the magnet, the magnetization of the magnet did consist in such a distribution. Such an equivalent distribution is a conception helpful in itself, inasmuch as it can be experimentally determined, and expresses exactly the manner in which the lines (unit tubes) of magnetic induction leave the surface. But to accuse it of misleading those who misunderstood it, is to put on the shoulders of Gauss and others who considered surface distributions a responsibility which is not theirs, and a blame which properly belongs to the perverse experimentalists who have insisted on determining the actual positions of "poles" in bar magnets, and on measuring other things equally indeterminate or non-existent.

But is the following statement quite free from possibility of misconstruction? "Gradually, however, new light dawned. It became customary, in spite of the mathematicians, to regard the magnetism of a magnet as something that traverses or circulates around a definite path, flowing more freely through such substances as iron than through other relatively non-magnetic materials." If any student of the subject does get into his head the idea that an actual material something flows round a magnetic circuit, he might quite as justly hold Dr. Thompson responsible for this false notion as blame the mathematicians for causing him to suppose a magnet to be a body plastered over with imaginary magnetic matter.

In tracing the evolution of the notion of magnetic permeability, Dr. Thompson might have made some mention of the contributions to molecular theory given by Poisson and others; for after all, these men really knew as well as we do "that magnetism, so far from residing in the end or surface of the magnet, is a property resident throughout the mass." But, as has already been stated, their attention was chiefly directed to the fields of permanent magnets; and to find a doctrine which "will afford a basis of calculation such as is required by the electrical engineer" is the business of the electrical engineer himself, and others interested in the problem Hitherto, indeed, so far as such a doctrine has been found, it has been discovered in great measure by the physical mathematician! The mathematical doctrine of "magnetic permeability," or—to use Faraday's phrase—"conductivity for magnetic lines of force," was given so long ago as 1872 by Sir William Thomson, and fully illustrated by analogies and applications; and it is certainly curious that so accurate an historian as Dr. Thompson should, in his historical *résumé*, have made no mention of this very important paper. It is also the fact that our knowledge of the properties of iron, which, with the "simple law of the magnetic circuit," constitutes, according to Dr. Thompson, the stock-in-trade of the designers of dynamos, has come in no small degree from the same source. The most eminent investigator and improver of the dynamo is also a mathematician; but perhaps, as Sir William Hamilton (of Edinburgh, not of Dublin!) said of a certain mathematician who, he was forced to admit, reasoned correctly, he did it in spite of his mathematics, not because of them.

All honour to the great mathematicians who first attacked the difficult subject of magnetic action. But even if they had sinned so grievously by their unpracticality as it seems now the fashion to try to make out, their successors, entering into their labours, have been able to do much to atone by helping the engineer in the difficulties which beset his advance into a region, viewed indeed from afar, but hitherto untrodden. In this great work the engineer and mathematician are necessarily companions, and for either to reproach the other, as to what happened or did not happen in the past, is only to provoke useless recrimination, and delay their onward progress.

It is time now to come to the subject-matter proper of the book, and for this we have, on the whole, nothing but commendation. There are some things which might, perhaps, have been expressed differently with advantage, but this, of course, is only a matter of opinion. In the first chapter a very interesting account is given of the inventions and researches carried out by Sturgeon, Henry, and Joule, and ends with a description of notable electro-magnets. The sketch of Sturgeon's career, given in an appendix to this chapter, is of remarkable interest as a plain unvarnished record of heroic toil in the pursuit of knowledge, carried on amid uncongenial surroundings, and in spite of the hard pinch of poverty. In happier circumstances, this experimental genius would no doubt have done much for science. Still, to us there is some compensation, for, had it not been for the *res angusta domi* of his later years, we might not have had his "Annals of Electricity" or his "Scientific Researches." As it is, it seems well established that he was the pioneer of electro-magnetic discovery, the maker of the first electro-magnet and the first magneto-electric machine; and Dr. Thompson has done a simple act of justice in bringing Sturgeon's claims in this respect before the great public now interested in the progress of electrical science.

In chapter ii. we have generalities concerning electro-magnets and electro-magnetism, descriptions of typical forms of electro-magnets, and materials of construction. First are discussed such topics as the uses of electro-magnets, magnetic polarity, magnetic units, and elementary propositions in electro-magnetism. Here we would remark, as a merit in this work, the fact that the author has not loaded what is intended to be a thoroughly practical treatise with long discussions of purely theoretical matters, however important in relation to practice. The sketches of theory given in many works—which are really only collections of tables of numerical data, lists of formulæ, and workshop recipes—would be much better left out, and their places supplied by other matter, or the books lightened by their absence.

An excellent chapter follows, on the properties of iron. The various methods of measuring permeability are well explained, and for the space devoted to it a good account (with tables) is given of the results obtained by Hopkinson and Ewing in their researches. On p. 108 the effect of opening gaps in a magnetic circuit of iron is discussed, and a reference is given to an experiment described later in the work. On turning to this experiment (p. 212), it is found to be a description of an exploration of the effect produced at different parts of a horseshoe steel magnet by pulling off the keeper. A narrow coil of a few turns of wire is wound on a light frame capable of being slided round the magnet, and is connected with a ballistic galvanometer. The effect of pulling off the keeper is then tested with the coil in different positions on the horseshoe, and is shown by the deflection of the needle of the ballistic galvanometer. The theory of the author is, that putting on or taking off the keeper of a permanent steel magnet does not affect the magnetization at the middle of the horseshoe; that by putting on the keeper, and so diminishing the magnetic "reluctance" of the circuit, the lines of magnetic force are only collected, not altered in amount. Hence, if this theory be true, the coil, when placed at the middle of the magnet, should show no effect on the removal of the keeper. It is stated that careful and repeated experiments made at Finsbury gave an effect at the middle of the magnet which did not amount to 1/3000 of that found when the coil was close up to either end of the magnet.

Some time ago, when informed by a friend of this statement and result, the writer, feeling extremely doubtful of their general truth, had a magnet constructed for the purpose of repeating the experiments. As a large magnet was required for other purposes, one was constructed of eight steel bars of a mean length of about 3 feet. Each bar was 2 inches broad by $\frac{1}{4}$ inch thick, so that when put together they formed a large horseshoe of square cross-section 2 inches in side. A keeper, made of a block of soft iron, fitted between the ends of the horseshoe. The steel, which was tool steel obtained from a local firm, took magnetism readily, and an excellent horseshoe magnet was obtained.

A coil in circuit with a ballistic galvanometer was used in the manner described above, to test the effect of removing the keeper. Careful experiments made by students, and repeated by the writer, gave an entirely different result from that obtained by Prof. Thompson. A very large throw was obtained by placing the coil close to either end of the magnet and detaching the keeper; but with the coil as nearly as possible at the middle of the horseshoe, the throw was about *one-eighth* of the maximum. It was verified, moreover, that the minimum throw was obtained at the middle.

This result was exactly what the writer had expected would in general happen. The so-called free magnetism at the extremities of the magnet, in the absence of the keeper, produced a demagnetizing effect throughout the magnet, and thus diminished the induction through the coil, even when at the middle. This action was counteracted by the magnetizing effect of the keeper when in position, and therefore itself inductively magnetized, but had full play as soon as the keeper was removed. The much greater deflections near the ends were undoubtedly due to the cause to which Dr. Thompson would assign the whole effect—the alterations of the arrangement of the lines near the ends which accompanied the removal and replacement of the keeper.

It is certain that this effect will depend on the permeability of the magnet steel, which is a function of the magnetization; but that such an effect will in general be produced there does not seem to be any room for doubt.

The following chapters deal with specially designed electro-magnets, such as, for example, those used in relays and clockwork, electro-magnetic mechanism, alternate-current electro-magnets, electro-magnetic motors and machine tools, and the purely electro-magnetic part of the book winds up with a very interesting chapter on the electro-magnet in surgery. The last chapter of all is devoted to permanent magnets. To give a satisfactory account of these chapters is here impossible; but it may be mentioned that the electro-magnetic mechanism fully described and figured includes no less than nine classes, beginning with the different forms of magnet with moving armature or plunger, magnets with armatures moving against counterpoises of different kinds, polarized devices, electro-magnetic vibrators, magnetic brakes, &c.

In chapter xi., on alternate-current electro-magnets, the modes of laminating magnets for the prevention of eddy-currents are described; then follows a discussion of effects of alternating electro-magnets, depending on the difference of the phase relations of the magnets and the eddy-currents excited in conductors in the form of disks and rings placed near the extremities of the iron cores. Thus we have a very interesting account of Elihu Thomson's remarkable experiments. The throttling or impedance effect of electro-magnets included in circuits is next treated. It would have been worth noticing, where the relations of maximum current, maximum electromotive force, mean current, mean electromotive force, and impedance are given, that the true mean value of the total electrical activity in an alternating circuit, in which work is done against resistance only, as in lighting glow-lamps, is equal to the mean square of the current multiplied by the total resistance in circuit.

In the chapter on the electro-magnet in surgery, Dr. Thompson, as was to be expected, gives a careful summary of the history of the subject. It seems that hitherto the principal use has been in ophthalmic surgery, for the extraction of small particles of iron from the eyeball. A very interesting case is narrated, in which the author's brother, Dr. Tatham Thompson, of Cardiff, successfully removed, by a magnetic probe constructed according to his own design, a fragment of iron which had passed through the eye of a blacksmith and lodged in the retina. The probe, excited by a coil, was inserted through the vitreous humour of the eye along the track of the wound, and catching the bit of steel, drew it from its resting-place in the retina. With the exception of a slight limitation of the field of vision, the patient perfectly recovered his sight.

The writer has a lively remembrance of being present some years ago at a search made, by means of a magnetic probe which he had arranged for one of the surgeons of Glasgow Infirmary, for a fragment of iron which was alleged to have entered the knee of a blacksmith. The blacksmith was exceedingly lame, and an examination of the knee by means of a magnetometer for signs of the presence of iron had resulted in some very puzzling indications. All iron, it was thought, had been removed from the patient, and with the knee in certain positions very decided indications of magnetized iron or steel had been observed. The probe, magnetized by a battery current, was inserted in an incision made at the place where the iron was supposed to have entered, but without effect. An adhesion was found to exist in the joint, and was broken down by the surgeon, with the result that after the patient's recovery the lameness had disappeared. It was found on stripping the patient that he wore a truss, and hence the magnetometer effects!

It seemed rather unlikely, in any case, that the magnetic probe would be effective in removing a splinter deeply embedded in muscular tissue.

The last chapter, on permanent magnets, though no part of the subject-matter proper of the book, is nevertheless very complete, and full of valuable information regarding the magnetizability of different kinds of steel, effects of temperature, use of laminated magnets, lifting power of magnets, and permanence of magnets with lapse of time.

The chapter concludes with a short sketch of astatic arrangements of needles. In connection with these, it may be remarked that the vertical pair of astatic needles—which has the advantage of perfect and permanent astaticism, inasmuch as each needle is astatic—was described, with other astatic arrangements, in a paper by Mr. T. Gray and the present writer, in the Proceedings of the Royal Society for 1884 (vol. xxxvi.).

Here we must take leave of a most interesting volume. The outside of the book is tastefully got up, the printing and paper are excellent, and the whole is worthy of the reputation of both author and publishers.

A. Gray.

FUNGUS EATING.

British Edible Fungi: how to Distinguish and how to Cook them. By M. C. Cooke. (London: Kegan Paul, Trench, Trübner, and Co., 1891.)

THERE is a fascination in the minds of many people for the eating of fungi, which has often been expressed in popular books on the subject by authors of various degrees of power. Some of these are enthusiasts, who suffer palpably from that malady of intolerance which characterizes so many propagandists, who would persuade us that those things are best to eat and drink which they have found so; others, again, temper their recommendations by the calm arguments of the scientific man, though, speaking as having found, they must write with a tinge of that persuasiveness necessary to overcome wide-spread prejudice, or ignorance, if they are to be understood by the multitude; others, again, are content to state the facts, and let the logic of their sentences make its own impression in due course.

It is not easy to say off-hand in which of these categories the writer of the book under review should be classed, nor is it of much consequence to look at his writings according to the decision arrived at in that connection. It is certainly no more than fair to say that Mr. Cooke has compiled a little book of no small value as a guide to common edible fungi of this country; and that, while the information is singularly clear, and told in plain and homely language, it loses little or nothing in the simple telling, so far as the facts about these cryptogams are concerned. In so far, the author's well-known reputation as a mycologist is not likely to suffer; but it must be added that, while we do not pretend to criticize in detail all that relates to the cooking of these delicacies, and while it must always be more or less a matter of individual opinion whether *Champignons* stewed with pepper and butter, or *Boletus* with sauce of lemon-juice and powdered lump-sugar, are the more delicious, there is something that smacks of prejudice in the more than hearty commendation of some of the cooked favourites. Be this as it may, Mr. Cooke is unquestionably a high authority on his subject, and he has done good service in supplying the public with a well-written account of it, and with excellent coloured drawings of about forty of the chief forms of edible fungi.

Few people in this country are aware that nearly two hundred of the things called toadstools are at least edible, and fewer still will be prepared to believe that there are people in the world who regard some fifty-odd of these as dainties. Mushrooms, truffles, and morels exhaust the list for most Englishmen, and many are dubious about even these, and eat them, when served, with various degrees of trustful confidence, or the reverse.

It is a severe shock to these persons when they learn that such species as *Amanita rubescens*, *Lepiota procerus*, *Coprinus comatus*, and other "horrid toadstools," may not only be eaten, but are even extolled as delicious; and when it comes to recommending the green-topped *Clitocybe odorus*, smelling of anise, or the purple *Tricholoma nudus*, and other violently coloured species, the amateur may be pardoned for hesitating. Nevertheless, these and many other forms popularly held as dangerous are not only edible, but are also capable of distinction with a